Bringing the Field to the Supervisor: Innovation in Distance Supervision for Field-Based Experiences Using Mobile Technologies

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Abstract

This paper provides a summary of the design, development, and evaluation of a mobile distance supervision system for teacher interns in their field-based teaching experiences. Developed as part of the University of Florida's Restructuring and Improving Teacher Education 325T grant project, the prototype system streams video of teachers in rural classrooms using iPad Minis equipped with a variety of peripheral devices to provide enhanced optics and multi-source audio. A description of the prototype, including hardware and software components, is provided.

Project Restructuring and Improving Teacher Education (RITE), a 325T grant project at the University of Florida (UF), is preparing special education teacher graduates to meet the Highly Qualified (HQ) requirements of the Individuals with Disabilities Education Act (IDEA; 2004). Specifically, graduates are prepared to (a) use highly effective, research-based practices to improve academic and behavioral outcomes for students with high incidence disabilities; (b) address the needs of students from culturally and linguistically diverse backgrounds; (c) collaborate with general educators to improve outcomes for students with disabilities who are educated in general education classrooms; and (d) improve student outcomes on high standards for learning in core academic subjects. A central focus of this grant project is the development and implementation of distance supervision models that effectively leverage technology to improve efficiency and cost-effectiveness in order to increase placement of UF teacher interns in rural schools.

Our goal is to establish a program in which teacher interns in remote, rural locations experience a strong connection to UF, while also receiving high quality performance feedback. Approximately 20% of elementary schools in Florida serve students in rural settings, including most of the schools in north central Florida near Gainesville. On average, 40% of the teacher interns at UF are either placed in rural schools or apply to be placed in rural schools. Due to limited resources, however, UF is unable to place all teacher interns in rural schools. Therefore, we are implementing a variety of distance education technologies, including asynchronous systems, such as the Canvas course management system, and synchronous systems, such as web conferencing, to increase our capacity to place teacher interns in rural schools. Through the adoption of online learning technologies, we are able to make the program accessible to teacher interns in various locations around the state, including high need schools. Fieldwork in regions beyond the area closely surrounding Gainesville, FL, has potential to give teacher interns opportunities for experiences in more diverse and high need rural schools that face a number of unique challenges, including fewer resources and highly qualified teachers (Brownell, Bishop, & Sindelar, 2005).

Distance Supervision in Project RITE

Pre-service, novice teachers need guidance as they translate research and training into practice in their classrooms (Billingsley, Griffin, Smith, Kamman, & Israel, 2009). Typically, this is achieved by supervising teacher interns through their field-based experiences in classrooms. Due to the significant management, time, and travel associated with traditional models of field-based teaching supervision, the costs to support such programs in rural schools are high. Supervising teacher interns' teaching experiences online from a distance enhance accessibility and convenience for both supervisors and teacher interns. Distance supervision, defined as the use of electronic telecommunications technology to provide field-based supervision to teacher interns who are not in the same location as the supervisor (McAdams & Wyatt, 2010), can reduce supervision costs and increase accessibility for supervisors and teacher interns.

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Interest in and exploration of distance supervision solutions for teacher interns in rural schools is growing (e.g., Bolton, 2010; Hager, Baird, & Spriggs, 2012; Rock et al., 2009; Routier & Otis-Wilborn, 2013). While understanding of how to create effective distance supervision systems is still emerging (Routier & Otis-Wilborn, 2013), reports of positive outcomes are beginning to emerge (Rock et al., 2009, 2012). For example, Bolton (2010) found that teacher interns reported that the technology was less intrusive than having a supervisor present; that teleconferencing promoted enhanced collaborations between supervisors, teacher interns, and partner teachers; and that teacher interns were able to receive more timely feedback.

A growing consensus exists among researchers that

Table 1.

System Requirements of Mobile Distance Supervision System

System Requirement	Requirement Description
Common	Components should be easy to purchase and affordable.
Interchangeable	If a component breaks or needs to be repaired a substitute can easily be found/purchased/sent and the system will still work.
Upgradable	Able to be upgraded as technology/needs change without prohibitive cost.
Intuitive	Although training is provided, system components should be easy to understand/connect.
Sustainable	In the future (i.e., post grant funding), students should be able to supply their own main device and then integrate university supplied system components (e.g., microphone, camera lens).
High Quality	Allow for clear audio that lets the supervisor hear primarily the student teacher but also the responses of students; Supports video streaming that clearly shows the student teacher including anything written on the board/ smart board/immediate teaching station AND a small subgroup of students.

Operational Requirement	Requirement Description
Adaptable	The system should function across a variety of school settings (e.g., regardless of the physical structure of the school building) and in a variety of different classroom environments.
Reliable	The system components and streaming solution should work (i.e., allow the supervisor to conduct the observation) during the majority of observations.
Ethical	Since there are multiple legal implications associated with recording and storing teachers and students the system operation should ensure that only streaming is being used (at least at this juncture) and that no recording is occurring.
Accurate	The system should allow the supervisor to accurately “observe” virtually enough of the teacher, classroom, and sample students in order to conduct a complete and thorough evaluation.

distance supervision can be used to supplement traditional supervision; however, there is much work to be done to develop efficient and effective systems that leverage technology while also retaining features of traditional face-to-face interactions. Current problems in need of solutions include connecting to and using school networks (which commonly have strict firewall rules; Hager et al., 2012), poor audio (Rock et al., 2012), inability to capture the "big picture" of what is happening in the classroom due to camera lenses' limited fields-of-view, poor video resolution (Gronn et al., 2013), and a general lack of mobility (Kelly & Bishop, 2013); however, these problems are not immutable. Application of new technologies with advanced capabilities has the potential to mitigate many of these problems. In the following section, we describe the design of a prototype distance supervision system that approaches these problems using Internet-connected mobile technologies.

iPad Mini-based Distance Supervision Prototype

Providing field-based classroom experiences in rural Florida schools beyond the Gainesville region has necessitated the development of online systems for supporting teacher interns in distance settings. Therefore, we developed an initial prototype for observing teacher interns in rural schools as they perform their field based teaching. At its core, the prototype distance supervision system uses an iPad Mini attached to a small tripod for recording videos and for transmitting the videos to field supervisors and mentors via live online streaming. The iPad Mini is ultra-mobile, has very good battery life, has a small form factor (important so as not to be obtrusive in the classroom), and is capable of recording and streaming with multiple quality settings. Our system approaches many of the problems that prior distance supervision systems have encountered by using removable wide-angle lenses, a wireless lavalier microphone for the instructor, a noise-cancelling microphone to capture classroom audio, and an LTE cellular data connection for ensured network connectivity. On the back-end, secure streaming solutions have been devised and implemented.

Rapid Prototyping

To design the prototype distance supervision system, we utilized a rapid prototyping (RP) design method. RP is a user-centric, evolutionary approach that allows designers to reduce development time and costs (Desrosier, 2011; Jones & Richey, 2000). RP focuses on quickly developing mock-ups and functional prototypes for testing and evaluation and iteratively advancing those prototypes into complete systems over time. The design process is recursive (Branch & Kopcha, 2014), within which product users participate and provide feedback over the course of multiple evaluation and revision cycles to help shape the product to satisfactorily meet requirements. The RP approach aligned with our design objectives in that it allowed for testing the effectiveness and appeal of our system and allowed us to work within the constraints of limited time and personnel.

Establishing Requirements

The design of the prototype system began with an assessment of program and system needs. First, the team established a set of requirements for the distance supervision system that fell into two categories: (a) system requirements and (b) operational requirements. System requirements were those features and functions that guided the development of the physical prototype, while operational requirements were the desired properties that the final system needed to embody (see Table 1).

Product Review

Next, we reviewed four systems that had been used for similar purposes: (a) Teachscape, (b) Polycom, (c) a remote teacher observation kit developed at the University of Kentucky (UK; Hager et al., 2012), and (d) an iPod Touch-based solution called Observation Analysis and Recording System (OARS; Kelly & Bishop, 2013). The product review evaluated each system to identify how well each met challenges associated with distance supervision systems noted in the literature (e.g., Gronn et al., 2013; Hager et al., 2012; Kelly & Bishop, 2013). We reviewed the audio and video quality, stability for streaming video, network connectivity, and portability of each system. To ensure broad utilization, we also considered total costs. First, we determined that Teachscape and Polycom would not meet our needs. The Teachscape system is not easily portable, and the setup is complicated and not user-friendly. The Polycom system we tested was portable and had the ability to pan, tilt, and zoom the camera; however, it was obtrusive and bulky. In addition, both systems were highly proprietary with nearly all components and software controlled by the vendor.

Next, we reviewed the UK and OARS systems because their designs provided us with ideas for developing our own system. The UK system utilized a tracker pod and an off-the-shelf high definition webcam to allow for panning and tilting of the camera from a distance. It also used a headset so that audio recordings of the teacher would be clear. These features allowed for a broader field-of-view and for high quality audio—both challenges noted in the literature. The OARS system utilized an iPod Touch as its video capture system. This allowed for ultra-portability and provided excellent battery life. We drew on these design features in the development of our system.

Last, we reviewed the web conferencing solutions. Both Skype and Google Hangouts provide free-to-use services, while Blackboard Collaborate operates on a paid software licensing model. With regard to video quality, we found that Google Hangouts and Skype can offer high quality video, but the quality is highly correlated to available bandwidth. In our product review, we experienced dropped connections, pixelated video, garbled audio, and mismatched and delayed audio. Blackboard Collaborate's video was immediately identified as being unacceptable, with very low frame-rates and notable pixilation. Therefore, none met our needs.

System Design

At its core, the prototype distance supervision system consists of iPad Minis with 4G-LTE cellular network connectivity. The iPads are equipped with wide-angle lenses to increase the camera's field of view. In addition, a wireless lavalier microphone is used to capture audio from teacher

Figure 1.

Diagram of Prototype Distance Supervision System

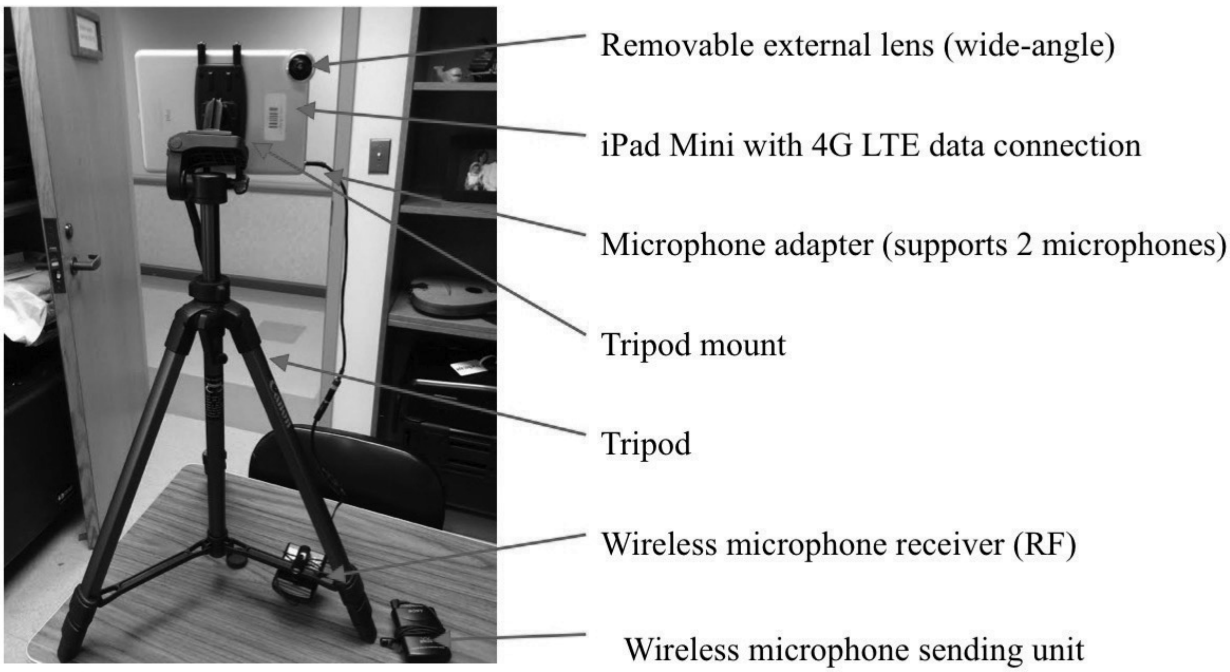
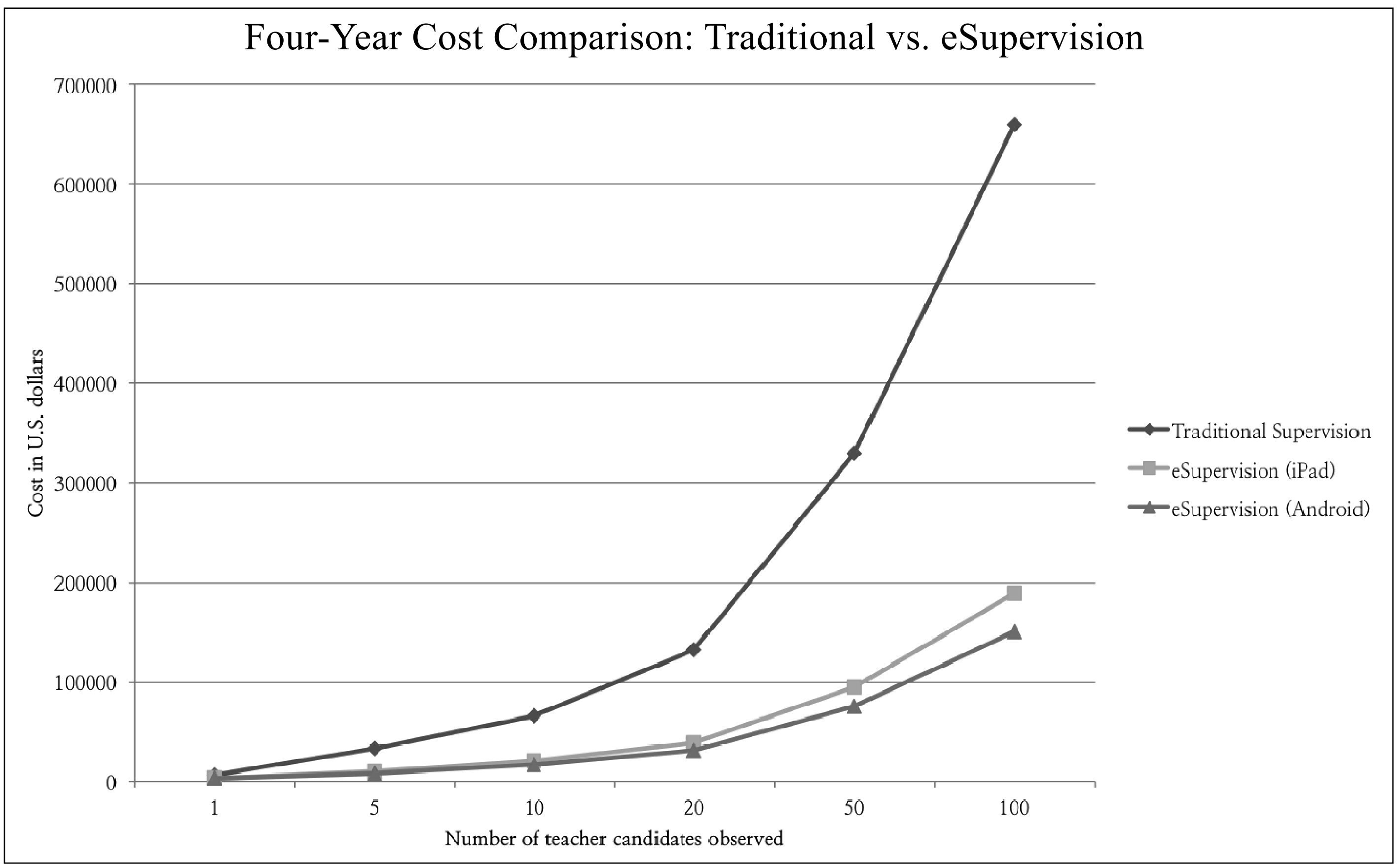


Figure 2.

Four-Year Cost Comparison of Traditional Supervision versus Distance Supervision Using iPads and Android Tablets.



interns, providing high-quality audio. An additional microphone can be attached to capture audio of the classroom. The iPad Minis are mounted to a small tripod. A diagram of the prototype is provided in Figure 1. Audio and video are streamed using H.264 adaptive bitrate streaming at up to 1080p high definition quality. On the client side, Wowza Media System's GoCoder app is used to encode the video stream. On the server side, Wowza Streaming Engine negotiates and streams the audio/video feed. The video stream can be viewed by supervisors through a password-protected webpage.

iPad Mini with 4G-LTE wireless networking. The decision to use the iPad Mini was based on cost, ease-of-use, quality and reliability of device, the iOS app ecosystem, and networking capabilities. By selecting the iPad Mini with 4G-LTE and 16GB storage, we were able to meet the design requirements of using a common device that is easily upgradable, intuitive, and of high quality. We were also interested in the iPad Mini because we intend in the future to support large numbers of teacher interns using these devices, and Apple provides tools to support mass deployments of their tablets, such as Apple Configurator and Mobile Device Management options built into their Mac OS X Server software. As with the OARS system (Kelly & Bishop, 2013), the iPad mini is highly portable and has very good battery life. In one of our tests, we were able to move our prototype unit into three different classrooms, move it to different groups in those classrooms, and stream over 2.5 hrs of nonstop video without needing to plug into a power source. We opted to use the iPad Mini over a device such as an iPhone or iPod Touch because the iPad Mini is more versatile and can be of value to teacher interns far beyond just a distance supervision device, given its larger screen size.

As we were performing our product review, concern about connecting to the Internet through partner school networks was a recurring theme. A goal of Project RITE is to serve teacher interns in rural schools across the state; however, different schools have different networks. Those networks have disparate access policies, firewall rules, peak usage times, bandwidth availability, etc. In order to reduce the complexity of connecting to the Internet, we chose to investigate cellular data options. This is an approach that has been explored in the past with 3G networks with less-than-satisfactory results (Gronn et al., 2013); however, with advancements in cellular data networks and video compression technologies, it is now possible to live stream high definition audio and video over a 4G-LTE connection.

Identifying a 4G-LTE provider required a general understanding of the amount of data that a single observation would require in order to predict the amount of data needed per month to support multiple observations. We performed field tests in which we streamed audio and video from various classrooms in Hawaii and Florida to capture information on the amount of data that was being used. We performed tests at different audio/video quality settings and with different bandwidth requirements (e.g., bitrate). On average, our system would require approximately 250 megabytes per hr of observation, which translated into a conservative estimate of approximately 18 gigabytes of data per month for five iPad Minis. We anticipate that this estimate is overly conservative, but provides sufficient buffer.

After identifying bandwidth needs, we were able to investigate wireless data providers. Key considerations when identifying a wireless provider with the intention of serving rural areas are data coverage and quality-of-service. Nearly all wireless data providers have coverage maps that include information on quality-of-service available on their websites. We anticipated that there could be some bias in company-provided coverage maps so we investigated crowdsourced coverage maps as well (e.g., www.sensorly.com). We determined that, for the state of Florida, the provider with the widest 4G-LTE coverage and best quality of service in rural areas was Verizon Wireless.

Wide-angle lens. A variety of wide angle and fisheye lenses are available for mobile devices from online vendors. These lenses are inexpensive and attach to the mobile device as a removable peripheral device. External lenses attach using a variety of mechanisms, such as clips, magnets, and dedicated cases. Because these lenses are common, interchangeable, upgradable, and intuitive, they were a good fit for our design requirements. We evaluated a number of these lenses for optical quality, field-of-view, and how well they attached to the iPad Mini. We were most pleased with lenses that attached using a magnetized ring. They are inexpensive and provide a fast and simple way to attach and detach lenses from the device. We also reviewed three different lens types: (a) wide angle, (b) fisheye, and (c) super fisheye. The wide angle lens provides a 67% wider field-of-view than the built-in iPad Mini camera. The fisheye lens provides a 180-degree field-of-view. The super fisheye lens provides a 235-degree field-of-view. These lenses were tested in low and bright lighting conditions and in different placements in a classroom (e.g., back of room, center of room, corner of room). Clarity of instructional materials at the front of the classrooms also was evaluated (e.g., slideshows, whiteboard). We found that there is a tradeoff between field-of-view, clarity of object in the periphery of the viewport, and the size of objects. As the field-of-view increases, objects in the viewfinder become smaller, hence impacting their clarity. Our evaluation revealed that the fisheye lens offered the best optics, clarity, and field-of-view for the price (under $10). We also found that placement of the device must be considered. Field-of-view accounts for a wide perspective but does not account for depth. Hence, a distance supervision device placed at the back of the classroom will not be able to capture activity at the front of the classroom with as much clarity as one placed near the front. Lower lighting conditions also impacted clarity.

Wireless lavalier microphone and microphone adapter. After network quality, audio quality is the most important factor when implementing distance supervision. Numerous problems with audio have been noted when using built-in microphones, such as an inability to hear the instructor or classroom noise being so loud that it is not possible to distinguish speech. The UK distance supervision system utilized a Bluetooth headset that teacher interns wore to ensure high quality audio (Hager et al., 2012). One advantage of Bluetooth is that it is wireless, allowing the instructor to freely move around the classroom; however, Bluetooth headsets can be difficult to set up and connect and need to have their batteries charged between uses. We opted to use more traditional radio frequency-based wireless lavalier microphones

(lapel microphones). The specific model we used was the Sony WCS999 Wireless Camcorder Microphone with a 3.5mm TRRS male to 3.5mm microphone adapter. We tested the wireless lavalier microphones in average-sized classrooms and a large lecture classroom. We tested in lecture format, small groups, and break-out groups. We found that the distance of the microphone from the receiving unit resulted in some distortion in the lecture classroom, but we observed no such distortion in the average-sized classrooms.

Streaming solution. In order to maintain control over quality of service for streaming, we opted to use an enterprise-grade audio/video streaming solution as opposed to a free-to-use service, such as Skype or Google Hangouts. We identified Wowza Streaming Engine as the media server software to stream audio and video to supervisors' devices. It offers an iOS app, GoCoder that allows the iPad Mini to live stream audio and video. Of particular interest is that the GoCoder app is optimized to allow for high definition streaming over a cellular data connection. It also allows for manipulation of the outgoing bitrate so as to provide the best quality stream. The primary benefit of using the Wowza Streaming Engine is that we have control over the server that live streams teacher observations. This allows us to maintain control over the quality-of-service for live streaming.

Cost/benefit evaluation. As a preliminary measure, we performed a cost comparison of our prototype distance supervision solution against traditional supervision methods. We started with the assumption that a supervisor in the state of Florida would take a 150 mile round trip for supervision in a rural placement at the current standard mileage reimbursement rate ($0.56 per mile) and the standard per-diem rate for a one-day trip ($51.00). We used the current model of providing three supervisions per student per semester. Using these data, we projected across 2 years what traditional supervision would cost versus distance supervision for 1 and 5 students. We also projected the same comparison across 4 years with 1, 5, 10, and 20 students.

We found that, in the short term, traditional supervision was more cost effective than the distance supervision system. Over 2 years, supervision of one student would cost $1,650 using traditional supervision, compared to $3,425 for distance supervision. Results were similar for five students over 2 years. However, when we scaled up the time and the number of students, we observed economies of scale for the distance supervision solution but not for traditional supervision. Over 4 years, the cost of one student would be $6,600 for traditional supervision and $3,425 for distance supervision. Based on these findings, we extended the analysis over 4 years for 100 teacher interns. We also included the use of Android devices as an alternative to the iPad Mini to determine the cost difference achieved over time by using a lower-cost tablet. Our findings are presented in Figure 2. With traditional supervision costs reaching above $650,000 and distance supervision costs below $200,000 after 4 years, findings suggest that distance supervision could have more than a 2/3 cost advantage over traditional supervision.

Discussion

The goal of this paper was to report on the design and rationale for a prototype mobile device-enabled distance supervision system at UF. At this point, we have completed development of the first version of the system and are beginning to field test the prototype. We have conducted one in-situ field test with both a face-to-face supervisor and a distance supervisor. Specifically, we had a supervisor conduct her first classroom observation and feedback session in the classroom with the teacher intern. Then, we had the same supervisor conduct her next classroom observation and feedback using the distance technology system we developed. We are still reviewing the data from this field test, but preliminary results indicate that the quality of supervisor comments on standard supervision forms is very similar. Supervisors' responses from a focus group interview indicate that audio and video were of sufficient quality to provide meaningful feedback to teacher interns; however, placement of the device is a challenge, particularly when students break into groups. Audio quality is very good for hearing the teacher intern, but supervisors reported difficulty hearing students clearly. Nonetheless, the system can support teacher interns and supervisors looking to perform their teaching practica in rural schools. It offers these teacher interns opportunities to teach in placements that they might otherwise not be able to use. While these initial results are positive, they are preliminary. Moving forward, we will be performing evaluation of our system by evaluating the usability, reliability, and quality of the prototype distance observation system.

Our future goals include scaling up from the prototype stage to the point where we can supervise all teacher candidates using distance supervision. We also would like to generalize the system beyond UF. We are confident that we will be able to meet these goals because we purposefully avoided highly proprietary systems. We have developed a system with components that are all interchangeable—from the lenses to the streaming software to the iPad Mini itself. If we determine in our evaluation that a certain component of the system is performing below expectations, we easily can change the component. By avoiding proprietary solutions, we are not locked into using a particular vendor and relying on that vendor to fix problems.

Our prototype system stands as an example of implementing distance supervision in rural schools. Providing pre-service special education teacher interns learning opportunities in rural settings is mutually beneficial for the teacher intern and the rural school. The teacher intern receives first hand experience working with some of the unique challenges faced by rural schools, including fewer resources and more high need students (Brownell et al., 2005). The rural schools, in turn, receive well-trained teacher interns to assist in myriad educational activities necessary to successfully serve rural students (Eppley, 2009). We believe that distance supervision has widespread application and can be cost-saving and an efficient system for increasing the quality of special education teachers serving high need students in hard to reach places.

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